# LANE USE CONTROL ON URBAN THOROUGHFARES

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by

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LANE USE CONTROL ON URBAN THOROUGHFARES

TO: K. B. Woods, Director
Joint Highway Research Project

September 18, 1957

FROM: H. L. Michael, Assistant Director

File: 8-4-11
Project C-36-17K

Attached is a final report entitled, "Lane Use Control on Urban Thoroughfares." This report has been prepared by Kevin A. MacNaughton, graduate assistant on our staff under the direction of Professor D. S. Berry. Mr. MacNaughton also utilized the report as his thesis for the degree of Master of Science in Civil Engineering.

This study includes the results of the use of lane controls and indicates conditions under which such controls appear advantageous.

Respectfully submitted,

Harold L. Michael

Harold L. Michael, Assistant Director
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FINAL REPORT

# LANE USE CONTROL ON URBAN THOROUGHFARES

by

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Joint Highway Research Project
Project No. C-36-17K
File No. 8-4-11

Purdue University
Lafayette, Indiana

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In the several cities that were visited, valuable assistance was given. The author wishes to acknowledge the aid of the following people.

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In Detroit, Mr. Holden LeRoy of the City of Detroit, Department of Streets and Traffic.

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The assistance of the Joint Highway Research staff was invaluable in the preparation of this thesis.

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# ABSTRACT

The purpose of this study was to investigate lane use controls in Lafayette, to determine an efficient method for gathering data on lane use, and to assemble information on lane use controls in several other cities.

Several recording methods were investigated, and a system was developed and tested utilizing adding machines as recorders.

Two adding machines and two operators recorded data for all four approaches of an intersection with lane use control in Lafayette, Indiana. The lane use control restricted the center lane, on all approaches, to left turning vehicles. The control on one leg was then changed to allow straight through vehicles to use both lanes of the approach. The capacities before and after change were compared.

In this study it was found that: Driver obedience to lane use controls in the Lafayette area is very good; this obedience increased when the lane lines and arrows on the pavement were repainted; when a "left-turn-only" lane is installed on an intersection approach with less than 10% left turns, capacity of the approach will be seriously impaired.

Introduction

Lane use control has become quite popular in several communities in Indiana and elsewhere, particularly for streets which normally carry one lane of traffic in each direction. Parking is usually prohibited in the approaches so as to provide two lanes for entering vehicles. Under this control one lane is restricted to one of the turning movements while the other lane handles the remaining traffic. Figure 1 shows how this control might operate at an intersection.

Two elements are considered important in analysing the operation of traffic at intersections. The first is the capacity of the intersection. When a change in the flow of traffic through an intersection is contemplated, will it increase or decrease the capacity of the intersection? The other element is safety. How will the change effect the chances of an accident occurring?

If any intersection is always overloaded in the peak hour, the solutions to be sought are those that will increase capacity. They must be checked by asking how the safety of the intersection will be affected. On the other hand, if the intersection has very few loaded cycles even during the peak hour but has a high accident rate, a change in favor of a safer method of allowing vehicles to enter the intersection would be indicated. Such a change should be checked from the capacity standpoint.

To determine whether the basis for the control under study in this report is primarily safety or capacity, some of its effects should be discussed.

Once the driver decides whether he wishes to turn right or left or go straight, under this control he need only learn what lane is provided for his desired movement and then proceed through the intersection in that lane. Figure 2 shows a typical overhead sign installation from which the proper lane can be easily determined.

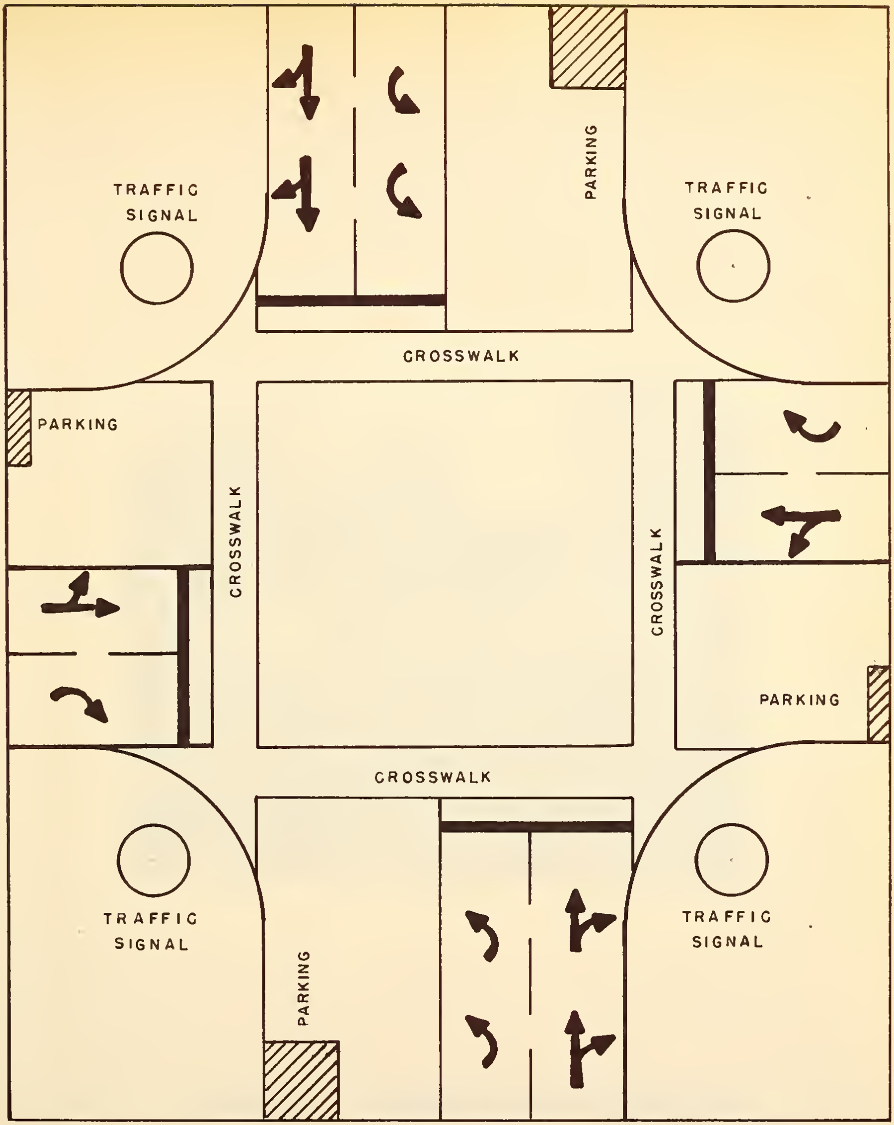



FIGURE 1 TYPICAL INTERSECTION WITH LANE USE CONTROL

FIGURE 2: OVERHEAD SIGNS ALLOW DRIVERS TO CHOOSE THEIR PROPER LANE IN ADVANCE

The control, then, removes some of the judgment needed without this lane designation. The driver approaching an intersection with a choice of two lanes and no special control must weigh the possible delay caused by left turning vehicles in the center lane, when opposing traffic blocks their exit, against delay caused by right turning vehicles in the curb lane when pedestrians block their exit. He then chooses a lane to pass straight through the intersection with the minimum delay.

If two vehicles come up to the intersection at the same time in adjacent lanes and both desire to go straight across, when there is only one exit lane, one vehicle must allow the other to go first or there will be a sideswipe accident. By preventing the use of two approach lanes by vehicles desiring to go straight through, this type of accident is reduced or eliminated. Thus, the control removes the conflict between vehicles moving in the same direction. It produces an orderly movement of vehicles and prevents the loss of time needed to allow vehicles from two lanes to merge into one within the width of the intersection.

The capacity value of this control, when only one exit is available, can be determined by comparing the number of vehicles clearing through the intersection, with the straight through movement using only one lane, to the number of vehicles clearing through when straight through traffic uses two lanes. Both turning movements will induce delays in the latter system but the chance that one lane will be free when the other is blocked will be reasonably good.

It is not within the scope of this study to make a detailed investigation of the possible psychological relief given drivers by limiting the lanes of approach to one, for any one exit direction. It should be pointed out, however, that the existing network of streets in most cities is such that this becomes a luxury which no city can afford if it gives relief at the expense of needed capacity. Drivers should be given every convenience that will make their driving easier and, at the same time, will not disrupt the efficient use of the community's streets.

If, on the other hand, this restriction has no detrimental effect on the capacity of the street, full use should be made of so economical a control as is studied here.

In order to determine when lane use control is desirable, studies should be made at many different intersections with varying percentages of turning movements with and without lane use control. It then would be possible to develop warrants for the lane use control. This research project was undertaken as a pilot study to investigate procedures, and to collect data for two intersections. Many more intersections should be studied before it would be possible to develop warrants for lane use control.

## Purpose

The purpose of this study is to:

1. Study specific intersections in the Lafayette metropolitan area to determine their capacity with and without lane use control. Intersections with varying percentages of turning movements will be studied to develop information for the establishment of warrants for the use of this control.
2. Assemble data and discuss lane use control practices in several cities.
3. Develop a new system to record traffic flow through intersections using adding machines as recorders.

Equipment and Its Operation

The basic data collected in the field for this study were volume counts. Some means of recording the number of vehicles, their type, lane of approach, and direction of exit had to be selected. In addition, a total count for each green phase had to be recorded with an indication of whether or not the approach was loaded during that phase.

Several methods of volume counting are now being used, but some type of keyboard device or a photographic record of the intersection traffic appeared to be required in order to collect all the necessary data.

When properly located, the camera will record all the action at the intersection. However, the time required to transcribe the data and the possibility of losing a day's collection in case the camera does not function properly led to the rejection of this method in favor of a keyboard in the hands of a trained operator.

At first it was thought that a set of keyboards could be connected to a multi-pen graphic recorder. This idea was discarded when it was realized that only slight modification need be made to the keyboard of an electric adding machine to convert it into an efficient recorder capable of recording many necessary and desirable data. Figure 3 shows a typical adding machine with its keyboard ready for volume data collection.

Two machines, each with one operator, are sufficient to collect and record, for each approach of a four-way intersection, the following data for each signal cycle:

1. Type of vehicle -- light or heavy.
2. Lane and order of approach of vehicle.
3. Exit direction of vehicle
4. Whether the particular leg being observed was loaded

FIGURE 3: THE ADDING MACHINE KEYBOARD SHOWING THE CODE CARD USED FOR INFREQUENT OCCURRENCES

5. up to seven predetermined descriptions of the traffic flow or other important information

6. total traffic per cycle, by movements

In this study, eight-column machines provided the required key arrangement for maximum speed and data capacity. Figure 4 shows a sample tape from the machine. From left to right the columns were used to record the following items:

Column 1:

Key 1 Light vehicles
2 Heavy vehicles
3 Vehicle in center lane at start of green
4 Pedestrians crossing
5 Driver delay
6 Vehicle stalled
7 Exit blocked
8 Bus stopped
9 Train

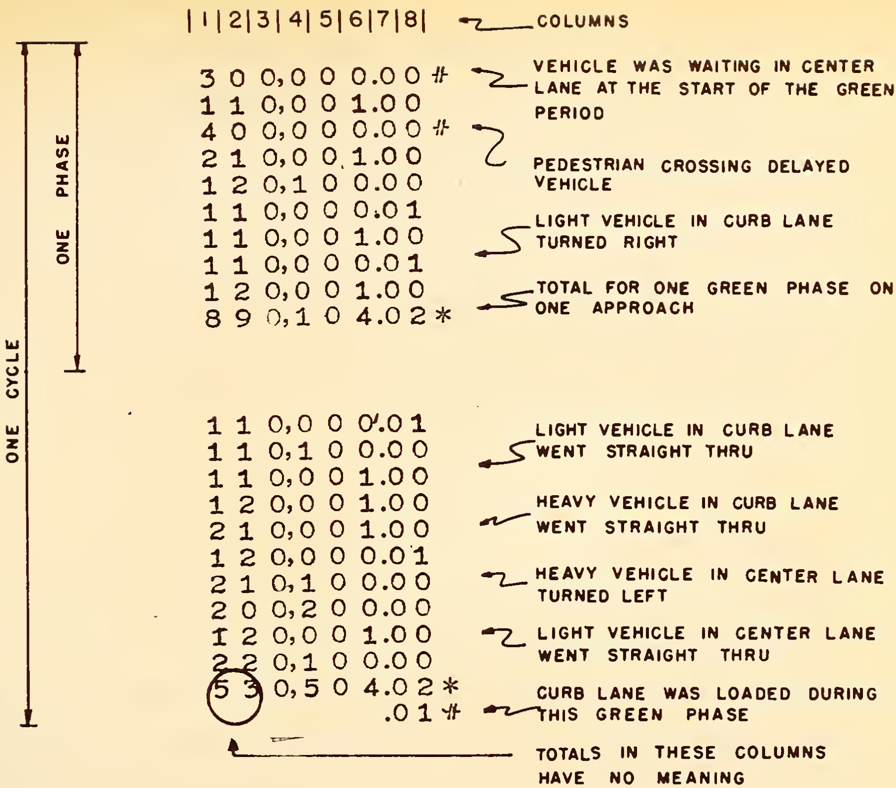
Keys one and two were used in combination with keys in other columns to give complete record of each vehicle. Keys three through nine were entered singly using the "non-add" key to affix a distinctive symbol to them.

Column 2:

Key 1 vehicle approached from curb lane
2 vehicle approached from center lane

Column 3:

This column was covered to separate columns 1 and 2 from column 4 and also to increase column 4's capacity from 9 to 99.




COLUMNS:

1 - VEHICLE TYPE CODE
2 - LANE CODE
3 - SHIELDED
4 - LEFT TURN
5 - SHIELDED
6 - STRAIGHT THRU
7 - SHIELDED
8 - RIGHT TURN

NOTE: ONE TAPE RECORDS THE DATA FROM ONE APPROACH ON EACH OF TWO STREETS

FIGURE 4 SAMPLE ADDING MACHINE TAPE

Column 4:

Key 1 vehicle exited to the left

no other keys were used

Column 5:

Covered as was column 3

Column 6:

Key 1 vehicle exited straight through

Column 7:

Covered as were columns 3 and 5

Column 8:

Key 1 vehicle exited to the right

Figure 4 shows how keys in columns 1, 2, 4, 6, and 8 recorded the complete movement of each vehicle passing through the intersection.

At the end of each green period, the "total" key was punched and the total traffic for that period was recorded by turning movements. After this total movement was recorded, column 8 was used to record a loaded green phase by punching in, with the "non-add" button, one of the keys coded as follows:

1 curb lane loaded

2 center lane loaded

3 both lanes loaded

A lane was considered loaded if more vehicles approached the intersection than were able to pass through during the green phase. A continuous line of vehicles had to be waiting to pass through the intersection throughout the green time, even though no vehicles were able to pass through at a particular time because of one of the reasons listed in column one, keys 4 through 9.

The tape can be read in the office similar to reading the tape from an automatic recording traffic counter. The recorded data can be quickly removed and summarized in the manner most convenient to the use to which it will be put. The time required to tabulate and summarize the data for four legs of an intersection from the adding machine tape is approximately one hour for each hour of data collected.

Figure 5 shows the machines set up at an intersection. Power to operate the machines was obtained from the traffic signal controller.

During most field studies, two machines and operators were used and all approaching vehicles were counted. Each operator recorded data for two legs of the intersection, selecting them for visibility. He alternated between the legs in accordance with the phase of green. No difficulty was experienced in keeping pace with traffic. The yellow period was used to "total" the traffic movement for the green phase that had just ended and to indicate loaded lanes when present. A line was then skipped before beginning to record the other directions. Occurrences, too rare to be given a code key, were written onto the tape in their proper location.

In addition to the main turning movements and lane use control obedience data, other items were recorded that are of interest to good traffic planning. As a natural result of the way the data was collected, it was easy to determine the number of trucks that turn right from the center lane. When a high percentage of trucks do this, it would presumably indicate the lack of a sufficient turning radius at the curb. Whenever a lane is restricted in use, this data collection method will immediately show up violations.


FIGURE 5: THE UPPER PHOTO SHOWS THE POWER CONNECTION USED AT THE INTERSECTION WHILE THE MACHINES IN USE ARE SHOWN IN THE LOWER PHOTO

By modifying the code to suit the investigator's needs, almost anything passing through the intersection could be counted. For instance, during the truck survey, the truck direction could be recorded together with a code for the company name. Immediately after that, a part of the truck's license could be recorded. By setting up a number of stations, truck movement in an area could be observed.

The smallest unit of time coordinated with the tape is in the time equal to the length of the green phase for any given approach. Within a green phase it is evident in what order vehicles passed. This will tell the investigator whether vehicles merged into one line, for instance, by alternating or if one lane pushed its way through and forced the other to wait. It will not indicate headways or, except by special notation, whether there was a gap between waves of vehicles approaching the intersection. For this study and for many others, time within a green phase is not essential. As long as data is recorded to indicate when the lane is full throughout a green period, the capacity of approach can be determined.

The volume count using adding machine recorders appears to attract no more attention from passers by than other methods. A few drivers watched the operation and forgot to watch the light. This caused some slight delay, but the number of incidents was very small.

Hand counters could be set up on a tally board to record the same data that could be recorded on the adding machine. However, six counters would be required to record three exit directions from each of two lanes. If heavy vehicles are to be separated from light vehicles, the number jumps to twelve. However, some exit directions could be eliminated. Right turns from the center lane and left turns from the curb lane are rare.

The recording of these movements could be eliminated but the information gathered would no longer be complete. If twelve counters are used, the operator must then make several decisions before recording each vehicle. When traffic is moving steadily through the intersection in two lanes, very little time can be given to deciding what lever to push. In addition to the difficulty of recording each vehicle properly, there is no provision for recording totals as the operator shifts from street to street. Therefore, each operator must have two boards and a third crew man is needed to transcribe the accumulations as the count progresses so that there will be a total per green phase classification. This still leaves the problem of how to indicate loaded cycles. The third man presumably can observe this as he transcribes data or the operators can tell him. This introduces an additional chance for error. The equipment cost of four tally boards each with twelve hand counters is very similar to the cost of two adding machines. The extra field man increases the cost of making the count with the tally boards.

With the keyboard-operator method, there is no danger of an unobserved machine failure. This will prevent the loss of valuable data. Though the record will not be as complete as with a camera recorder, the data will be easier to handle in the office.

The adding machine recorder has definite advantages in data capacity, ease of recording, and cost over the tally-board-hand counter method. The tape from the adding machine is easier to handle than that from the graphic recorder as the former is much smaller. In addition it is easier to read since there are only eight columns instead of twenty.

More coding can be accomplished with the adding machine since ten keys are available in each column. However, the graphic recorder has a constant speed tape advance which will coordinate time with the other data. Depending on the speed at which the graphic recorder must be run to distinguish between vehicles, tape replacement may become a problem when an extended count is made.

The cost of two adding machines is approximately one half that of a graphic recorder. The adding machine method is less expensive both in equipment and manpower. The machines themselves can be used for general office work when they are not being used for volume counts.

Regular 120 v.a.c. current must be used to operate the adding machines, while storage batteries can be used to operate the graphic recorder. The power to operate the adding machines, however, can be readily supplied at a signalized intersection through the signal controller.

Data Collection and Analysis

I. Procedure

The volume data necessary for this study was gathered over a period of three months in the late spring and early summer of 1957.

Two intersections were chosen after all possible intersections in the Lafayette area were inspected. To produce the most general conditions, only right-angle, four-way intersections were considered. In addition only those with two-phase signals and lane use controls were regarded as acceptable. These restrictions reduced the number of intersections to four of which only two had sufficient traffic flow to indicate their capacity.

The intersection of State and Grant Streets in West Lafayette was chosen as one location. However, due to an accelerated construction program the intersection was closed to the normal flow of traffic soon after the data collection began and before sufficient data had been gathered to produce any results.

The study was then concentrated at one intersection -- that of South and 4th Streets, in Lafayette.

Volume counts were made using the adding machine recorders described in the previous chapter. It was first thought that off peak traffic flows would be of interest but after a few days this was abandoned since it was found that the relatively minor flows had no difficulty in passing through the intersection.

Data were collected for three days over a three week period at South and 4th Streets with the lane use control restricting the center lane to left turn movements. During this time arrangements were made with the City of Lafayette to change the control to allow straight through movement from both lanes, from the west on South Street. Parking on the exit side of South Street from 4th to 5th Streets was removed at the same time to provide a two-lane exit for the safety of the motorists who, as a general rule, have been educated to expect only one through lane. At the same time, this provided a comparison between one and two approach lanes when there are two exit lanes. This comparison can be made since traffic forced to use one approach lane will use only one exit lane whether two are provided or not.

This change was effected on Monday, June 10, 1957. At the same time the lane markings on the other legs were renewed. Up to this time the lane markings on all the approaches had been almost obliterated by the traffic. The overhead signs, however, were in very good condition. Figures 6 and 7 show a plan of the intersection with the pavement markings before and after the change. Figures 8 thru 11 picture the approaches after the change.

On the Saturday preceding the initiation of the new control, an article explaining it appeared in the Lafayette Journal and Courier.

After the change was made, data were collected on nine afternoons during June and July. It was found that drivers seemed reluctant to use the center lane to go straight across the intersection. Since all intersections in the area with lane use control permit straight through movement from only one lane, it was thought that the motorists were failing to notice the change in control. To remedy this, an instruction sheet was passed out to each driver who stopped at a traffic signal three blocks west of 4th Street on South. In this way the motorist had a chance to read the sheet and then maneuver his vehicle into the lane of his choice.

The instruction sheets were passed out between four and five-thirty p.m. on June 17, 1957. A copy of the sheet may be found in the appendix.

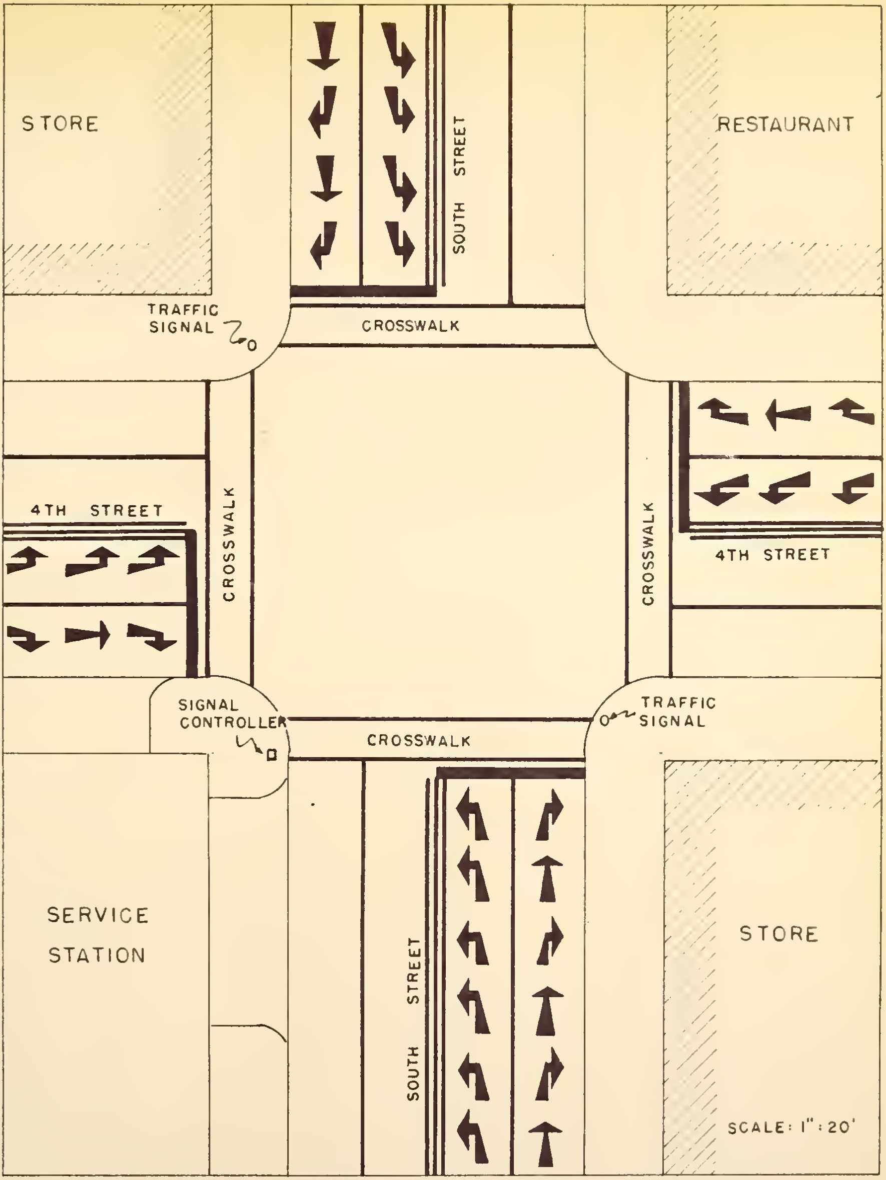



FIGURE 6. PAVEMENT MARKINGS BEFORE CHANGE IN LANE USE CONTROL

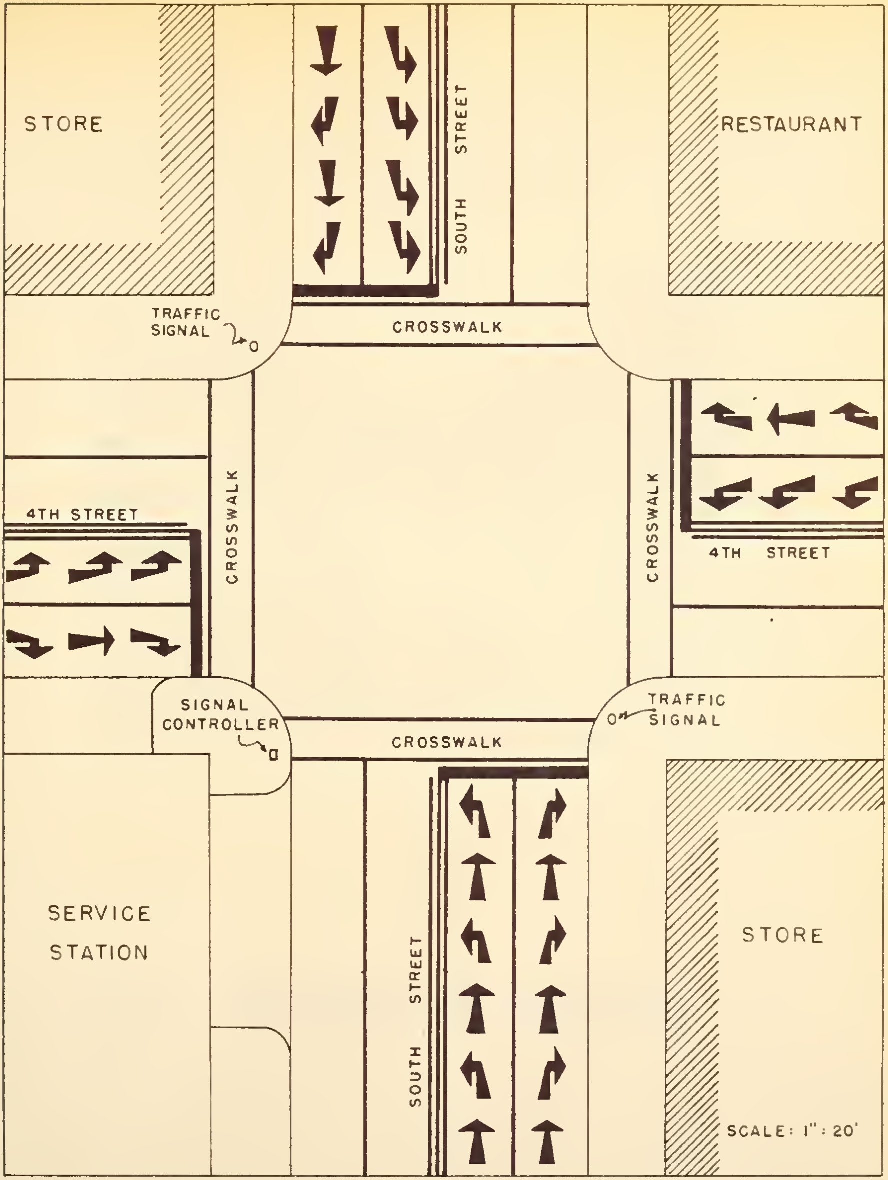



FIGURE 7 PAVEMENT MARKINGS
AFTER CHANGE IN LANE USE CONTROL


FIGURE 8: WEST APPROACH ON SOUTH STREET AT THE INTERSECTION OF SOUTH AND 4TH STREETS


FIGURE 9: EAST APPROACH ON SOUTH STREET AT THE INTERSECTION OF SOUTH AND 4TH STREETS


FIGURE 10: SOUTH APPROACH ON 4TH STREET AT THE INTERSECTION OF SOUTH AND 4TH STREETS


FIGURE 11: NORTH APPROACH ON 4TH STREET AT THE INTERSECTION OF SOUTH AND 4TH STREETS

Since loaded cycles were determined to be the item to be compared it was desirable to get as many such cycles as possible. To this end a group of eight drivers were assembled and instructed to drive through the west approach of the intersection at the same overall speed as the rest of the traffic.

They were told to pick whichever lane they thought would allow them to proceed straight through the intersection with the least delay. After going through the intersection, they circled around two blocks and again approached 4th Street from the west. By repeating this operation, many cycles were loaded. It is assumed that the average driver will drive the same as these special drivers after a learning period is provided.

Accident information was obtained from the Lafayette Police Department, but no accidents directly attributable to the lane use control could be found. Collision diagrams for the intersection can be found in the appendix.

## II. Tabulation and Summary

The data are tabulated in tables 2 thru 5 in the appendix. Average values for the important factors are given below.

Intersection of South and 4th Streets:

South Street:

| | From the West | Before* | After |
|---|---|---|---|
| | % left | 7.3 | 4.8 |
| | % thru | 66.4 | 69.6 |
| | % right | 26.3 | 25.5 |
| | % violations of lane use control | 2.6 | 0 |
| Between 4:45 & 5:15 pm | % using center lane | 8.4 | 27.4 |
| | % cycles loaded | 69.2 | 49.5 |
| | volume | 214 | 245 |

* Before here refers to the time before the lane use control was changed.

| | From the East | Before** | After |
|---|---|---|---|
| | % left | 18.0 | 18.9 |
| | % thru | 64.4 | 65.0 |
| | % right | 17.7 | 16.0 |
| Between 4:45 & 5:15 pm | % using center lane | 16.3 | 21.8 |
| | % cycles loaded | 20.5 | 21.2 |
| | volume | 162 | 157 |

** Before refers to the time before lane lines were repainted.

## 4th Street

| From the South | | Before** | After |
|---|---|---|---|
| | % left | 26.5 | 26.8 |
| | % thru | 57.7 | 57.6 |
| | % right | 15.8 | 15.6 |
| | % violation of lane use control | 4.4 | 0.5 |
| Between 4:45 & 5:15 pm | % using center lane | 27.5 | 27.1 |
| | % loaded cycles | 0 | 1.9 |
| | volume | 168 | 183 |

| From the North | | Before** | After |
|---|---|---|---|
| | % left | 11.0 | 10.0 |
| | % thru | 72.7 | 77.7 |
| | % right | 16.3 | 12.3 |
| | % violations of lane use control | 15.2 | 4.9 |
| Between 4:45 & 5:15 pm | % using center lane | 20.7 | 13.1 |
| | % cycles loaded | 0 | 3.8 |
| | volume | 176 | 182 |

** Before refers to the time before the lane lines and arrows were repainted.

Intersection of State and Grant Streets

State Street (Lane use control restricts center lane to left-turning vehicles only)

From the West

| | | |
|---|---|---|
| | % left | 7.4 |
| | % thru | 89.4 |
| | % right | 3.2 |
| | % violations of lane use control | 3.4 |
| Between 4:45 & 5:15 pm | % using center lane | 9.8 |
| | % cycles loaded | 88.3 |
| | volume | 306 |

From the East

| | | |
|---|---|---|
| | % left | 5.0 |
| | % thru | 79.5 |
| | % right | 15.5 |
| | % violations of lane use control | 2.8 |
| Between 4:45 & 5:15 pm | % using center lane | 4.2 |
| | % cycles loaded | 16.7 |
| | volume | 226 |

Grant Street

From the South

| | | |
|---|---|---|
| | % left | 10.4 |
| | % thru | 58.1 |
| | % right | 31.6 |
| | % thru vehicles using center lane* | 69.3 |
| Between 4:45 & 5:15 pm | % using center lane | 52.8 |
| | % cycles loaded | 13.3 |
| | volume | 122 |

* no lane use control exists on Grant Street.

From the North

| | | |
|---|---|---|
| | % left | 51.7 |
| | % thru | 24.4 |
| | % right | 23.8 |
| | % thru traffic using center lane* | 28.2 |
| Between 4:45 & 5:15 pm | % using center lane | 54.3 |
| | % cycles loaded | 41.7 |
| | volume | 208 |

* no lane use control exists on Grant Street.

Table 1 gives the number of loaded cycles and the average number of equivalent light vehicles or passenger cars passing through intersection during these loaded cycles.

Figures 12 and 13 show the 24 hour volume from the west on South Street. The curb lane traffic shown as a percentage of the total traffic so the area between the corner indicated the center lane traffic.

TABLE 1

AVERAGE NUMBER OF CARS THRU THE INTERSECTION
of
SOUTH AND 4TH STREETS PER LOADED CYCLE
WEST APPROACH

| Date | | Number of Loaded Cycles | | Average No. Cars Through * |
|---|---|---|---|---|
| **Before** | | | | |
| 4/30/57 | | 39 | | 9.2 |
| 5/14/57 | | 70 | | 8.9 |
| 5/28/57 | | 77 | | 8.0 |
| | Total | 186 | Average | 8.6 |
| **After** | | | | |
| 6/6/57 | | 10 | | 8.2 |
| 6/14/57 | | 17 | | 8.9 |
| 6/17/57 | | 10 | | 10.1 |
| 6/19/57 ** | | 30 | | 11.5 |
| 6/21/57 | | 20 | | 8.5 |
| 6/24/57 ** | | 31 | | 10.8 |
| 6/25/57 ** | | 11 | | 9.8 |
| 7/2/57 | | 22 | | 9.8 |
| 7/9/57 ** | | 24 | | 9.7 |
| | Total | 175 | Average | 9.9 |

* Heavy vehicles were equated to cars by multiplying by two.

** Special drivers used.

Figure 12 gives data for the period when only the curb lane could be used for straight movements. Very little traffic then used the center lane. When the lane use control was changed, more traffic used the center lane as can be seen in Figure 13. This is especially true in the peak period when extra capacity is needed.

## III. Statistical Analysis

Two analyses were carried out on the volume data collected at the intersection of South and 4th Streets.

The first and most important analysis concerned itself with the number of vehicles able to pass through the intersection. A before and after study was made on the eastbound South Street Approach. The data used was the average number of equivalent passenger cars that were able to pass through this approach in the loaded cycles. Heavy vehicles were equated to passenger cars by multiplying by two. Light vehicles were converted to the passenger car designation using the same numbers.

Once a relatively large number of loaded cycles had been accumulated for both conditions, a test could be made using the $\bar{c}$ statistic or the average number of passenger cars in a loaded cycle.

By use of

$$Z = \frac{\bar{c}_1 - \bar{c}_2}{\sqrt{\bar{\bar{c}}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where $Z$ = no. of std. dev. from hypothesized mean difference

$\bar{c}_1$ = avg. no. of passenger cars per loaded cycle after the lane use control was changed

$\bar{c}_2$ = avg. no. of pass. cars per loaded cycle before change was made

$\bar{\bar{c}}$ = weighted average of $\bar{c}_1$ and $\bar{c}_2$

$n_1$ = no. of loaded cycles recorded after the change

$n_2$ = no. of loaded cycles before the change

it was possible to determine whether the change in lane use control significantly affected the capacity of the intersection. A one tailed test was used to indicate whether significantly more cars are able to pass through the intersection when straight through vehicles can use two approach lanes.

Table 1 gives the data used to find the values used in the following computation:

$\bar{c}_1 = 9.9$ $\qquad \bar{c}_2 = 8.6$ $\qquad \bar{\bar{c}} = \dfrac{c_1 n_1 + c_2 n_2}{n_1 + n_2}$

$n_1 = 175$ $\qquad n_2 = 186$ $\qquad c = \dfrac{9.9 \times 175 + 8.6 \times 186}{175 + 186}$

$$z = \frac{9.9 - 8.6}{\sqrt{9.2\left(\frac{1}{195} + \frac{1}{186}\right)}}$$

$$\bar{\bar{c}} = \frac{1732.5 + 1599.6}{361}$$

$$z = \frac{1.3}{.32} = 4.06\ ^{**}$$

$$\bar{\bar{c}} = 9.2$$

Since $4.06 > 2.33$ this is significant at the 1% level. It can be claimed that more cars are able to pass through this intersection in the eastbound direction when two approach lanes are open to straight through vehicles. This claim can be made with only a one percent chance of error. The second analysis was made to determine if painting the lane lines and arrows on the other three legs significantly decreased the number of violations of the lane use control. A before and after study was made here also which coincided with the study in the previous

** Significant at the 1% level

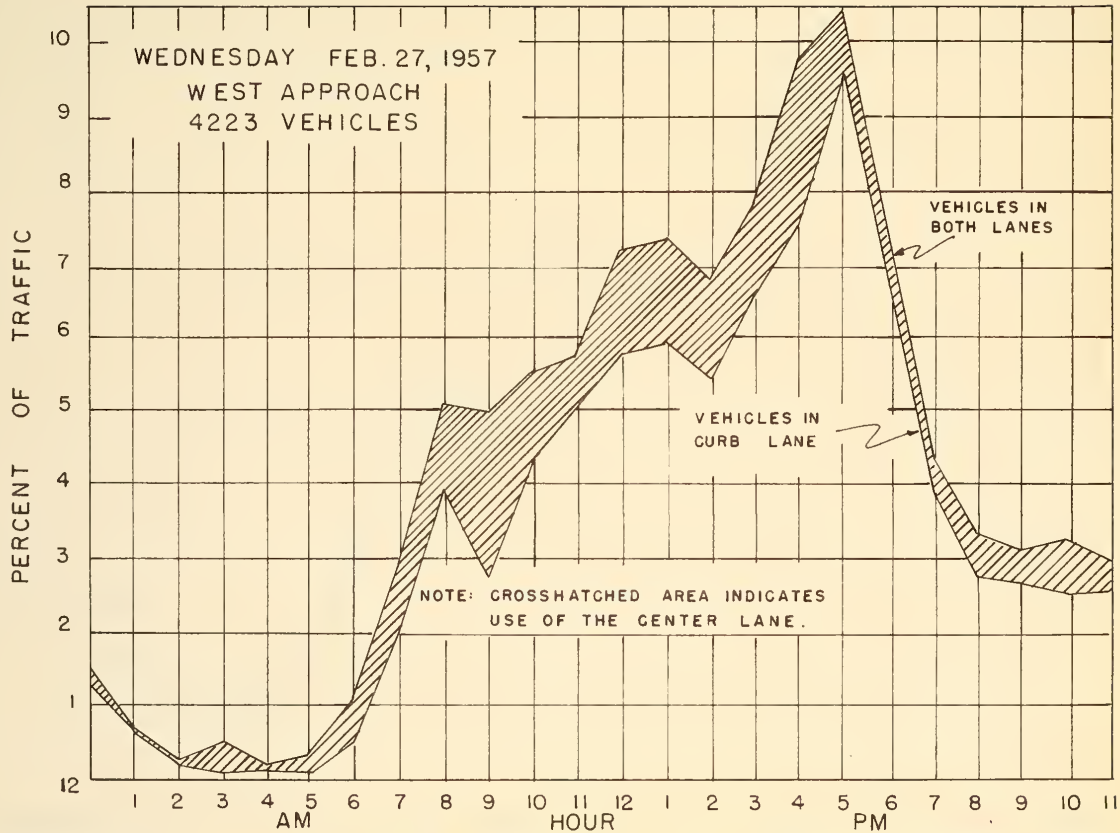



FIGURE 12 24-HOUR TRAFFIC VOLUMES BEFORE THE CHANGE IN LANE USE CONTROL

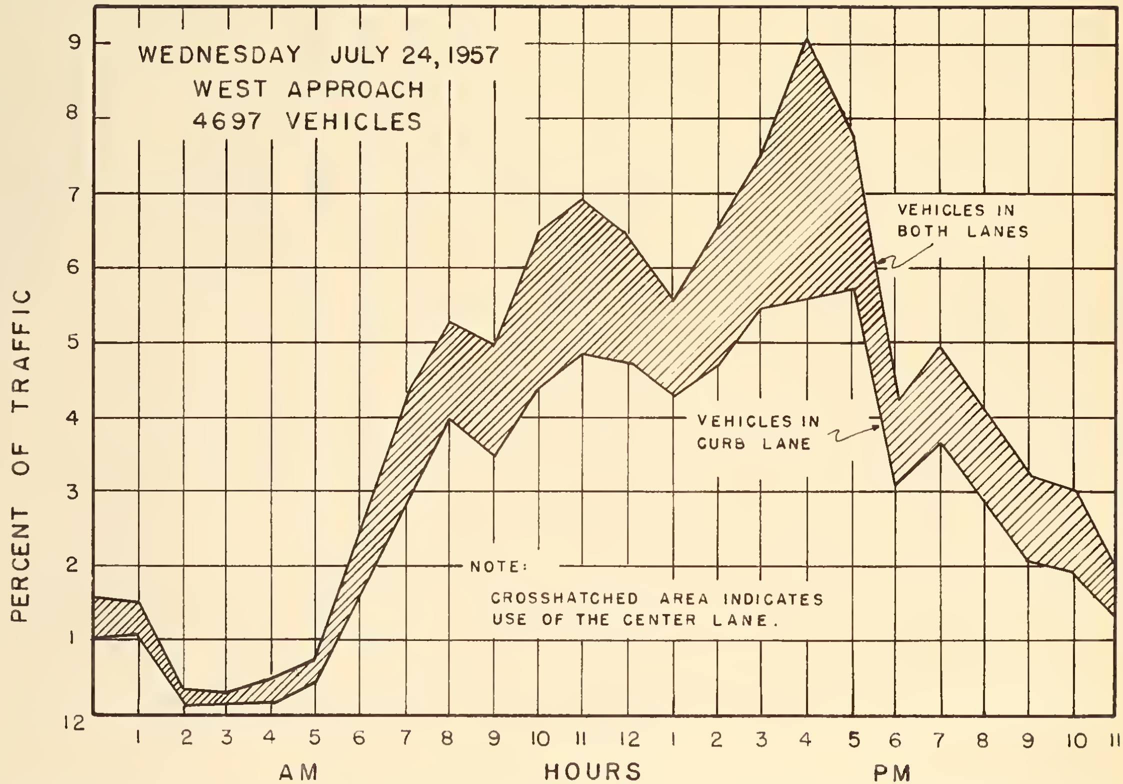



FIGURE 13 24-HOUR TRAFFIC VOLUMES AFTER THE CHANGE IN LANE USE CONTROL section. At the time the control was changed on the eastbound approach, all lane lines and arrows were revewed.

For this analysis the violations were expressed as a percentage of the straight through movement since only straight through vehicles were considered as violators. The formula used was

$$z = \frac{\bar{p}_1 - \bar{p}_2}{\sqrt{pq\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where $\bar{p}_1$ = decimal fraction violating before

$\bar{p}_2$ = decimal fraction violating after

$p$ = weighted average of $p_1$ and $p_2$

$q$ = $1 - p$

$n_1$ = number of vehicles going straight along the street on which they approach the intersection before painting.

$n$ = number of vehicles going straight along the street on which they approach the intersection after painting.

A one tailed test was also used here to indicate whether the violations dropped significantly after the painting was done. The three remaining legs were tested. Since more violations could be anticipated during times of light traffic, care was taken to use only data taken at comparable times. The time period was approximately 4:30 to 5:30 p.m.

For South Street - from the east.

$$p = \frac{\bar{p}_1 n_1 + \bar{p}_2 n_2}{n_1 + n_2} \qquad \bar{p}_1 = .026 \qquad n_1 = 469$$

$$\bar{p}_2 = .010 \qquad n_2 = 1019$$

$$q = 1 - .015 = .985$$

$$p = .015$$

$$z = \frac{.026 - .010}{\sqrt{.015 \times .985\left(\frac{1}{469} + \frac{1}{1019}\right)}}$$

$$z = \frac{.016}{\sqrt{0.000046}} = \frac{.016}{.00678} = 2.36^{**}$$

Since $2.36 > 2.33$, it can be claimed that painting decreased the violations of the lane use control with a 1% chance of error.

For 4th Street - from the south:

$\bar{p}_1 = .031$ $\qquad n_1 = 481$ $\qquad p = \frac{481 \times .031 + 1096 \times .005}{481 + 1096}$

$\bar{p}_2 = .005$ $\qquad n_2 = 1096$ $\qquad p = 0.013$

$q = 1 - .013 = .987$

$$z = \frac{.031 - .005}{\sqrt{.013 \times .987 \left(\frac{1}{481} + \frac{1}{1096}\right)}}$$

$$z = \frac{.026}{\sqrt{.0000385}} = \frac{.026}{.0062} = 4.19^{**}$$

Since $4.19 > 2.33$, it can be claimed that painting caused a decrease in violations on this approach with a 1% chance of error.

For 4th Street - from the north:

$\bar{p}_1 = .124$ $\qquad n_1 = 683$ $\qquad p = \frac{683 \times .124 + 2021 \times .046}{683 + 2021}$

$\bar{p}_2 = .046$ $\qquad n_2 = 2021$ $\qquad p = .066$

$q = 1 - .066 = .934$

$$z = \frac{.124 - .046}{\sqrt{.066 \times .934 \left(\frac{1}{683} + \frac{1}{2021}\right)}}$$

$$z = \frac{.078}{\sqrt{.00012}} = \frac{.078}{.011} = 7.09^{**}$$

Since $7.09 > 2.33$, it can be claimed that painting caused a decrease in violations on this approach with a 1% chance of error.

## IV Discussion

The data indicate that the amount of left turns from a particular intersection leg has a major effect on the value of the lane use control. When the use of the center lane from the west on South Street was opened to straight-through vehicles as well as left-turning vehicles, the lane began to carry almost 30% of the traffic instead of less than 10%. The number of loaded cycles went down and the num er of vehicles through in each cycle went up.

From the 24 hour volumes chart showing the results of a count made after the change, it can be seen that about 40% of the drivers during the peak period used the center lane. During the off peak periods, their use of the lane was not much different than before the change.

Where the percentage of left turns if greater, there is an indication that the center lane is better used. While the data is not sufficient to make a statistical analysis of all the intersection legs, it does show that some center lanes are well used while others are not.

The number of violations of this control are very low in Lafayette. The test at South and 4th shows obedience approaching that shown to the traffic signals themselves. This is especially true after the lane lines and pavement arrows were repainted. This may or may not be found to be true in other cities where this control might be adopted.

While the percentage violations were in the order of two of four percent at three approaches of the intersection, they were much higher on one approach. The only apparent difference was the fact that parking was permitted for about one half of the block leading to the intersection on the approach with relatively high violations. Adequate data was not available to prove whether this was the reason, but such a condition might be checked carefully where straight through traffic is to be moved from the center lane to the curb lane at an intersection.

Lane Use Control Survey

The purpose of this chapter is to gather, in one report, information on types of lane use control being used in other cities. While these controls may be solutions to problems now existing in some communities, a study of the particular circumstances in each locality should be made before determining whether any one of the several controls can be used to advantage. As are most traffic controls, they are double edged swords and, when used improperly, they will cut capacity instead of delay.

The first section deals with the types of markings used in the lane use control studied in other chapters of this report. Figure 14 shows the type of pavement marking arrows used to designate the type of movement allowed in a particular lane in Lafayette. The thick heads are highly visible and the direction indicated is very clear. Figure 15 shows the overhead signs that are used in conjunction with the pavement markings. Again thick headed arrows are used to show clearly the proper direction. These signs are reflectorized white arrows in a green background.

Figure 15 shows the most widely used control, which restricts the center lane to left turn movements. On one-way streets, where several lanes are available, heavy left turns can be accommodated as shown in Figure 16. On two-way approaches to intersecting one-way streets, the ordinary type of lane use control separates the two allowed movements as in Figure 17. An example of overhead signs combining the arrow symbol with a word message is illustrated by Figure 18. The use of the word "only" on this sign, patterned after lane use signs in Denver, points up the fact that a left turn is required of vehicles in this lane.

When using these markings, driver confusion can be eliminated by always indicating exactly what the motorist is required to do.

FIGURE 14: PAVEMENT MARKINGS FOR LANE USE CONTROL


FIGURE 15: OVERHEAD SIGNS SHOWING THE CENTER LANE RESTRICTED TO LEFT-TURNING VEHICLES


FIGURE 16: WIDE STREETS ALLOW GREATER LANE DISTRIBUTION


FIGURE 17: TWO-WAY APPROACH TO A ONE-WAY STREET


FIGURE 18 ARROW SYMBOLS ARE BEST COMBINED WITH WORD MESSAGES TO SIGNIFY REQUIRED MOVEMENT

A few confusing installations are shown in Figure 19 and 20. In Figure 19 pavement markings indicate a left turn may be made from the center lane which also carries the straight through movement. The overhead signs seem to indicate that the center lane is for straight through movements only. In Figure 20 the leaves of a nearby tree obscure the overhead sign. In this figure, also, the curb lane is designated as a straight through lane only, even though right turns may be made.

Heavy turning movements can be handled by allowing more than one lane to turn where there is sufficient approach and exit width. In such a case the inside lane will be restricted to the turning movement and the next lane will be either for the turn only, or for an optional turn lane. Figure 21 shows a double left turn control in Detroit. The curb lane is marked "Left Only", while the next lane is marked "Left", indicating an option of left or straight. Figure 22 shows a similar installation in Chicago.

Where a turn is permitted on an arrow indication while the red-indication is on, the particular lane affected is reserved for that purpose in Detroit. Figure 23 shows a right turn lane. Right turns on red may be made on red only when a supplementary arrow indication is given. Two types of arrows are used. One, a green arrow, allows a turn without stopping. Where heavy pedestrian volumes are encountered, a flashing red arrow is used. This requires the vehicle to stop before turning.

In California and some other states, right turns are allowed on red at all intersections unless otherwise signed. Ray (2) in a thesis for the Institute of Transportation and Traffic Engineering of the University


FIGURE 19: INACCURATE MARKING WILL CAUSE DRIVER CONFUSION. NOTICE THE PAVEMENT MARKINGS PERMIT A LEFT TURN BUT THE OVERHEAD SIGNS DO NOT.

FIGURE 20: NO RIGHT TURN IS INDICATED HERE ALTHOUGH ONE CAN BE MADE. TREES HAVE BEEN ALLOWED TO HIDE ONE OVERHEAD SIGN.


FIGURE 21: DOUBLE LEFT TURN MARKINGS
IN DETROIT


FIGURE 22: DOUBLE LEFT TURN MARKINGS IN CHICAGO


FIGURE 23: SPECIAL RIGHT TURN LANE IN DETROIT

of California reports that accidents involving right-turn-on-red with no auxillary indications accounted for only 0.3 of 1% of the total accidents in San Francisco Bay area over eight years. In addition only four pedestrian accidents involving a right-turn-on-red vehicle were reported in 3338 accidents studied by Mr Ray He reports travel times through a Central Business District were reduced from 7-10% over similar vehicles making a right-turn-on-green only

On major arterials in Detroit, the lighter traffic flow is often stopped early at intersections where many left turns are to be made by the heavier opposing traffic. This eliminates the danger of the lighter traffic starting up with the opposing traffic, even though their light is still red at delayed green controls. Detroit feels that there is better storage and more efficient use of the left turn opportunity with this control.

Many of these same arteries in Detroit have a nine foot lane straddling the center line of the street for the exclusive use of left turn vehicles. This makes for an efficient use of an odd lane and only removes four and one-half feet from each side of an evenly laned street. For wide streets, this can be divided among three or four lanes and not be missed. Figure 24 shows the overhead sign used to indicate the lane in Detroit. West Lafayette, Indiana is installing this on a five-lane street. In Chicago the centerline of some intersections is moved to the left to provide for a left turn storage area. This is shown in Figure 25.


FIGURE 24: SIGN OVER LANE STRADDLING RESTRICTED CENTER LINE IN DETROIT.

FIGURE 25: CENTER LINE ON CHICAGO STREET IS MOVED TO PROVIDE LEFT TURN LANE.

Where the traffic flow is predominantly in one direction in the morning and reverses itself in the evening, reversible lanes may be the solution to the capacity problem. There are many methods of operating reversible lanes which appear to depend to a large extent on how well the motorists are expected to operate over the streets. Chicago's Lakeshore Drive has concrete fins which can be raised and lowered to separate traffic. Figure 26 shows the center fin up. In Detroit two signs are alternated over the center of Grand River, one reading in the outbound direction "Keep Off Center Lanes 7AM - 9AM Monday thru Friday." This can be seen in Figure 27. The other reads "Use Both Lanes 4PM - 6PM Monday thru Friday." In the inbound direction, the times are reversed. No other control is used. Buffalo is installing a system similar to Detroit's, using signs over all lanes and illuminated turn prohibitions where necessary.

The results of this study indicate that a combination of pavement markings and overhead signs produces the best driver observance for lane use controls. When restricting a lane to one turn movement, the word "only" should be added to the arrow symbol to make the intent of the control clearly regulatory rather than merely permissive. Where double left or right turns are allowed the inside lane should be marked as a "turn-only" lane both on the pavement and on the overhead signs.

Turns made during a red indication are shown in various ways in different areas. The manual on Uniform Traffic Control Devices (1) mentions that permitting any movement through a red signal with no other indication weakens the effect of the red signal. However, in areas where right-turns-on-red are allowed, there appears to be no lessening of obedience

FIGURE 26: REVERSIBLE LANES ON CHICAGO'S LAKESHORE DRIVE.


FIGURE 27: REVERSIBLE LANE CONTROL
IN DETROIT.

to the red signal. Mr. T. T. Wiley, Director of the New York City Department of Traffic thinks that arrows of the same colors as traffic signals should be used to indicate allowed and prohibited movements. The most important item to consider is uniformity. There should be as much uniformity in this control as in the colors of the traffic signal itself. Why should a person find a large assortment of arrows and signs as he travels any more than he would expect to find purple and orange traffic signals?

When many left turns are made along the length of the street, the placing of a special lane straddling the center of the street appears to be a fine method of allowing the turns without delaying other traffic. Of course the width of the street is an important factor. A street width less than 50 feet would be too narrow for this control.

Unbalanced flow is quite different than the usual flow along a street. Even the crown of the street works against the acceptance of this method of providing extra capacity. However, the reason for large volumes moving in one direction is that the same people go to the same place every day and these people will quickly learn to use this control. Detroit uses the barest minimum of signs for their system. Chicago has elaborate fins to divide the opposing traffic. Traffic on a street is divided unevenly only during rush hours, and the rush hour traffic is made up of people who use the street day after day. The author is of the opinion that under many conditions only signs or signals and some pavement markings are needed to operate the unbalanced flow once the commuters get used to it.

Conclusions and Recommendations

1. Driver obedience to lane use controls in the Lafayette area is very good. In many locations it approaches behavior usually reserved for traffic signals only.

2. At the intersection studied obedience to the lane use control was increased when the lane lines and arrows were repainted.

3. When a "left-turn-only" lane is installed on an intersection approach with less than 10% left turns, an inefficient use of the approach results. During times of high volume, delay will increase greatly.

4. Further studies are needed to determine the limits that should be set on the use of this lane use control. The intersections approach studied here has a low left turn volume and a high right turn volume. The "left-turn-only" lane did not produce an efficient use of the approach. Presumably, as left turns increase in number, they will reach a point where the center lane may well be restricted to their use. The condition of high right turns creating a need for a "right-turn-only" lane should also be studied. The study of more intersections will, under the proper conditions, allow generalization to warrants that will allow the most beneficial use of lane use control on urban thoroughfares. The possibility of reducing accidents with this control should be considered. A study of accidents should be made.

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# APPENDIX

TABLE 2

SOUTH STREET TRAFFIC - EASTBOUND

| Date | Hours | Volume | % left | % thru | % right | % heavy vehicles | % thru traffic using center lane | 1/2 hour period 4:45-5:15 p.m. volume | % cycles loaded | % using center lane | % using curb lane |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Before[1] | | | | |
| 4/30/57 | 3:15-4:55 | 636 | 7.2 | 65.3 | 27.5 | 3.6 | 0.0[2] | 225[5] | 73.07 | 7.55 | 92.45 |
| 5/14/57 | 3:15-5:30 | 884 | 7.9 | 67.2 | 24.9 | 4.5 | 2.2 | 217 | 88.46 | 6.91 | 93.09 |
| 5/28/57 | 2:30-5:30 | 1096 | 6.2 | 67.9 | 25.9 | 7.2 | 1.6 | 214 | 88.46 | 8.87 | 91.13 |
| 6/6/57 | 4:15-5:30 | 510 | 8.0 | 65.1 | 26.9 | 5.9 | 3.9 | 201 | 26.92 | 10.44 | 89.56 |
| Average | | | 7.3 | 66.4 | 26.3 | 5.3 | 2.6 | 214 | 69.23 | 8.44 | 91.56 |
| | | | | | | | After | | | | |
| 6/14/57 | 4:35-5:30 | 417 | 5.8 | 65.7 | 28.5 | 1.9 | 24.5[3] | 246 | 19.23 | 24.79 | 75.21 |
| 6/17/57 | 4:35-5:31 | 434 | 3.5 | 65.0 | 31.6 | 2.3 | 30.9 | 241 | 23.16 | 24.89 | 75.11 |
| 6/19/57[4] | 4:35-5:26 | 487 | 4.1 | 74.9 | 20.9 | 2.7 | 39.5 | 283 | 73.07 | 34.98 | 65.02 |
| 6/21/57 | 4:39-5:30 | 358 | 6.7 | 66.8 | 26.5 | 5.3 | 25.5 | 208 | 42.30 | 21.15 | 78.85 |
| 6/24/57[4] | 4:13-5:23 | 624 | 5.1 | 70.8 | 24.0 | 3.2 | 36.2 | 284 | 73.07 | 34.15 | 65.85 |
| 6/25/57[4] | 4:26-5:30 | 426 | 6.3 | 70.2 | 23.5 | 5.4 | 27.8 | 209 | 26.92 | 27.75 | 72.25 |
| 7/2/57[4] | 4:44-5:33 | 383 | 5.0 | 70.7 | 24.3 | 2.5 | 26.6 | 238 | 57.09 | 23.10 | 76.90 |
| 7/9/57[4] | 4:23-5:19 | 445 | 2.2 | 72.8 | 24.9 | 2.2 | 35.8 | 251 | 80.76 | 28.28 | 71.72 |
| Average | | | 4.8 | 69.6 | 25.5 | 3.2 | 20.6 | 245 | 49.52 | 27.39 | 72.61 |

1. "Before" designates time before lane-use control was changed.
2. Violation of lane-use control.
3. Permitted movement.
4. Special drivers used.
5. 4:25 - 4:55 p.m.

# TABLE 3

## SOUTH STREET TRAFFIC - WESTBOUND

Before[1]

| Date | Hours | volume | % left | % thru | % right | % heavy vehicles | % thru traffic using center lane | 1/2 hour period 4:45-5:15 p.m. volume | % cycles loaded | % using center lane | % using curb lane |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4/30/57 | 3:15-4:55 | 490 | 17.8 | 61.6 | 20.6 | 2.4 | 3.3 | 137[3] | 34.61 | 15.32 | 84.68 |
| 5/14/57 | 3:15-5:30 | 688 | 16.9 | 66.3 | 16.9 | 3.3 | 2.0 | 162 | 11.53 | 16.04 | 83.96 |
| 5/28/57 | 2:30-5:30 | 871 | 19.3 | 65.2 | 15.6 | 5.6 | 3.2 | 168 | 15.38 | 17.55 | 82.45 |
| Average | | | 18.0 | 64.4 | 17.7 | 3.8 | 2.8 | 162 | 20.51 | 16.30 | 83.70 |
| **After** | | | | | | | | | | | |
| 6/19/57 | 4:25-5:26 | 284 | 18.0 | 60.5 | 15.5 | 0.4 | 2.1 | 174 | 38.46 | 19.54 | 80.46 |
| 6/21/57 | 4:39-5:31 | 297 | 18.2 | 64.6 | 17.1 | 1.6 | 1.0 | 172 | 15.38 | 19.18 | 80.82 |
| 6/24/57 | 4:13-5:23 | 296 | 18.6 | 65.2 | 15.2 | 4.4 | 0.5 | 138 | 11.53 | 30.07 | 69.93 |
| 6/25/57 | 4:26-5:39 | 284 | 20.1 | 65.8 | 14.1 | 2.4 | 0 | 168 | 7.69 | 18.75 | 81.25 |
| 7/2/57 | 4:44-5:33 | 260 | 15.8 | 70.8 | 13.5 | 4.2 | 0 | 167 | 7.69 | 14.97 | 85.03 |
| 7/9/57 | 4:23-5:19 | 235 | 21.7 | 57.4 | 20.9 | 2.5 | 2.2 | 124 | 46.15 | 28.22 | 71.78 |
| Average | | | 18.9 | 65.0 | 16.0 | 2.6 | 1.0 | 157 | 21.15 | 21.79 | 78.21 |

1. "Before" designates the time before the lane lines and arrows were repainted.
2. Violation of lane-use control.
3. 4:25-4:55 p.m.

TABLE 4

FOURTH STREET TRAFFIC - NORTHBOUND

Before[1]

| Date | Hours | volume | % left | % thru | % right | % heavy vehicles | % Thru Traffic Using Center Lane[2] | 1/2 hour period 4:45-5:15 p.m. volume | % cycles loaded | % using center lane | % using curb lane |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4/30/57 | 3:15-4:55 | 540 | 22.6 | 60.4 | 17.0 | 5.7 | 2.5 | 171[3] | 0 | 26.31 | 73.69 |
| 5/14/57 | 3:15-5:30 | 709 | 29.3 | 56.6 | 41.1 | 5.5 | 5.2 | 165 | 0 | 27.87 | 72.13 |
| 5/28/57 | 2:30-5:30 | 965 | 27.7 | 56.1 | 16.3 | 8.0 | 5.4 | 169 | 0 | 28.40 | 71.60 |
| Average | | | 26.5 | 57.7 | 15.8 | 6.4 | 4.4 | 168 | 0 | 27.53 | 72.47 |
| | | | | | | | After | | | | |
| 6/19/57 | 4:35-5:26 | 289 | 28.0 | 58.1 | 13.8 | 3.8 | 1.2 | 172 | 3.84 | 33.72 | 66.28 |
| 6/21/57 | 4:39-5:31 | 324 | 26.5 | 55.0 | 18.5 | 2.5 | 1.1 | 179 | 0 | 26.81 | 73.19 |
| 6/24/57 | 4:13-5:23 | 403 | 24.6 | 59.8 | 15.6 | 5.5 | 0.8 | 200 | 7.69 | 22.82 | 77.18 |
| 6/25/57 | 4:25-5:30 | 336 | 27.7 | 57.7 | 14.6 | 5.4 | 0 | 179 | 0 | 28.48 | 71.52 |
| 7/2/57 | 4:44-5:33 | 277 | 25.6 | 59.2 | 15.2 | 5.0 | 0 | 172 | 0 | 22.09 | 77.91 |
| 7/9/57 | 4:23-5:19 | 359 | 28.4 | 55.8 | 15.9 | 7.6 | 0 | 198 | 0 | 28.78 | 71.22 |
| Average | | | 26.8 | 57.6 | 15.6 | 5.0 | 0.5 | 183 | 1.92 | 27.12 | 72.88 |

1. "Before" designates the time before the lane lines and arrows were repainted.
2. Violation of the lane-use control.
3. 4:25-4:55 p.m.

TABLE 5

FOURTH STREET TRAFFIC - SOUTHBOUND

Before[1]

| Date | Hours | Vol- ume | % left | % thru | % right | % heavy vehicles | % thru traffic using center lane | 1/2 hour period 4:45-5:15 p.m. vol- ume | % cycles loaded | % using center lane | % using curb lane |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4/30/57 | 3:15-4:55 | 534 | 11.0 | 70.2 | 18.7 | 3.6 | 12.8 | 176[3] | 0 | 18.75 | 81.25 |
| 5/14/57 | 3:15-5:30 | 699 | 10.6 | 75.4 | 14.0 | 3.3 | 15.7 | 167 | 0 | 22.15 | 77.85 |
| 5/28/57 | 2:30-5:30 | 889 | 11.5 | 72.4 | 16.1 | 5.1 | 17.1 | 184 | 0 | 21.19 | 78.81 |
| Average | | | 11.0 | 72.7 | 16.3 | 9.0 | 15.2 | 176 | 0 | 20.70 | 79.30 |
| **After** | | | | | | | | | | | |
| 6/14/57 | 4:35-5:30 | 359 | 9.2 | 74.7 | 16.2 | 1.7 | 6.7 | 193 | 3.84 | 13.47 | 86.53 |
| 6/17/57 | 4:35-5:31 | 306 | 10.8 | 80.4 | 8.8 | 4.2 | 3.7 | 185 | 3.84 | 14.05 | 85.95 |
| 6/19/57 | 4:35-5:26 | 295 | 8.8 | [illegible] | 9.8 | 1.0 | 5.0 | 185 | 0 | 12.43 | 87.57 |
| 6/21/57 | 4:39-5:31 | 304 | 7.2 | 78.9 | 13.8 | 1.0 | 8.3 | 174 | 0 | 10.34 | 89.66 |
| 6/24/57 | 4:13-5:23 | 380 | 13.4 | 77.6 | 8.9 | 2.6 | 5.8 | 158 | 0 | 16.45 | 83.55 |
| 6/25/57 | 4:26-5:30 | 402 | 9.7 | 78.1 | 12.2 | 3.0 | 2.9 | 188 | 0 | 9.57 | 90.43 |
| 7/02/57 | 4:44-5:33 | 321 | 10.0 | 76.3 | 13.7 | 2.8 | 2.9 | 192 | 3.84 | 14.06 | 85.94 |
| 7/09/57 | 4:23-5:19 | 308 | 11.0 | 74.0 | 14.9 | 2.2 | 4.1 | 177 | 0 | 19.12 | 85.88 |
| Average | | | 10.0 | 77.7 | 12.3 | 2.3 | 4.9 | 182 | 1.44 | 13.06 | 86.94 |

1. "Before" designates the time before the lane lines and arrows were repainted
2. Violation of lane-use control
3. 4:25 - 4:55 p.m.

TABLE 6

TRAFFIC on GRANT and STATE STREETS

GRANT STREET - Northbound

| Date | Hours | Vol-ume | % left | % thru | % right | % heavy vehicles | % thru traffic using center lane | 1/2 hour period 4:45-5:15 P.M. vol-ume | % cycles loaded | % using center lane | % using curb lane |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5/2/57 | 3:50-5:30 | 300 | 12.0 | 61.7 | 26.3 | 0.3 | 73.5 [2] | 126 | 10.00 | 60.31 | 39.69 |
| 5/3/57 | 3:45-5:45 | 321 | 8.7 | 54.5 | 36.8 | 0.3 | 65.1 | 117 | 16.67 | 45.29 | 54.71 |
| Average | | | 10.4 | 58.1 | 31.6 | 0.3 | 69.3 | 122 | 13.34 | 52.80 | 47.20 |
| **Southbound** | | | | | | | | | | | |
| 5/2/57 | 3:50-5:30 | 506 | 51.8 | 25.5 | 22.7 | 0.8 | 24.0 [2] | 192 | 36.67 | 56.25 | 43.75 |
| 5/3/57 | 3:45-5:45 | 711 | 51.6 | 23.3 | 25.0 | 0.6 | 32.5 | 225 | 46.67 | 52.44 | 47.56 |
| Average | | | 51.7 | 24.4 | 23.8 | 0.7 | 28.2 | 208 | 41.67 | 54.34 | 45.66 |
| **STATE STREET - Eastbound** | | | | | | | | | | | |
| 5/2/57 | 3:50-5:30 | 1043 | 7.1 | 89.2 | 3.7 | 1.8 | 3.0 [1] | 331 | 83.33 | 10.27 | 89.73 |
| 5/3/57 | 3:45-5:45 | 1222 | 7.7 | 89.6 | 2.8 | 2.9 | 3.8 | 281 | 93.33 | 9.25 | 90.75 |
| Average | | | 7.4 | 89.4 | 3.2 | 2.4 | 3.4 | 306 | 88.33 | 9.76 | 90.24 |
| **Westbound** | | | | | | | | | | | |
| 5/2/57 | 3:50-5:30 | 720 | 5.4 | 80.6 | 14.0 | 2.8 | 2.9 [1] | 225 | 3.33 | 3.55 | 96.45 |
| 5/3/57 | 3:45-5:45 | 880 | 4.5 | 78.4 | 17.0 | 2.5 | 2.6 | 228 | 30.00 | 4.82 | 95.18 |
| Average | | | 5.0 | 79.5 | 15.5 | 2.6 | 2.8 | 226 | 16.66 | 4.18 | 95.82 |

1. Violation of lane-use control
2. Permitted movement

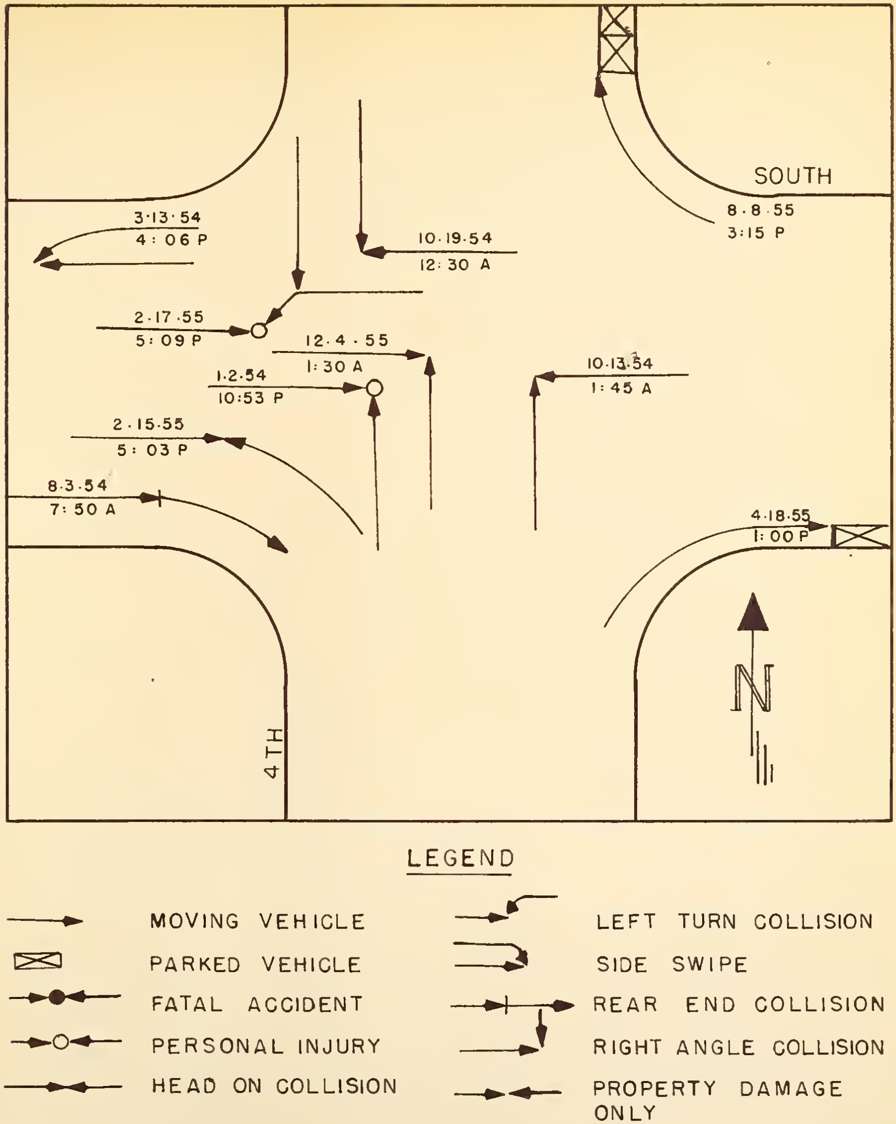


FIGURE 28 COLLISION DIAGRAM
SOUTH STREET AT FOURTH 1954-55

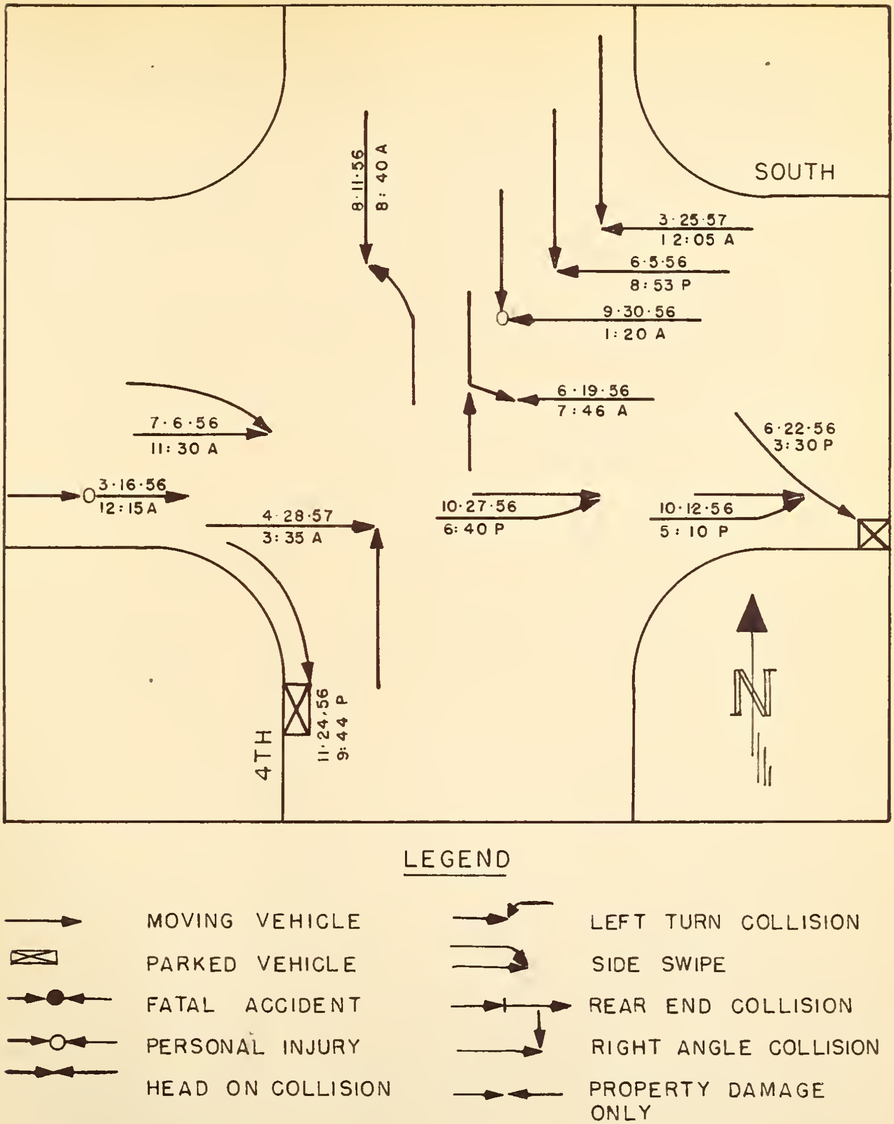


FIGURE 29 COLLISION DIAGRAM
SOUTH STREET AT FOURTH 1956-57

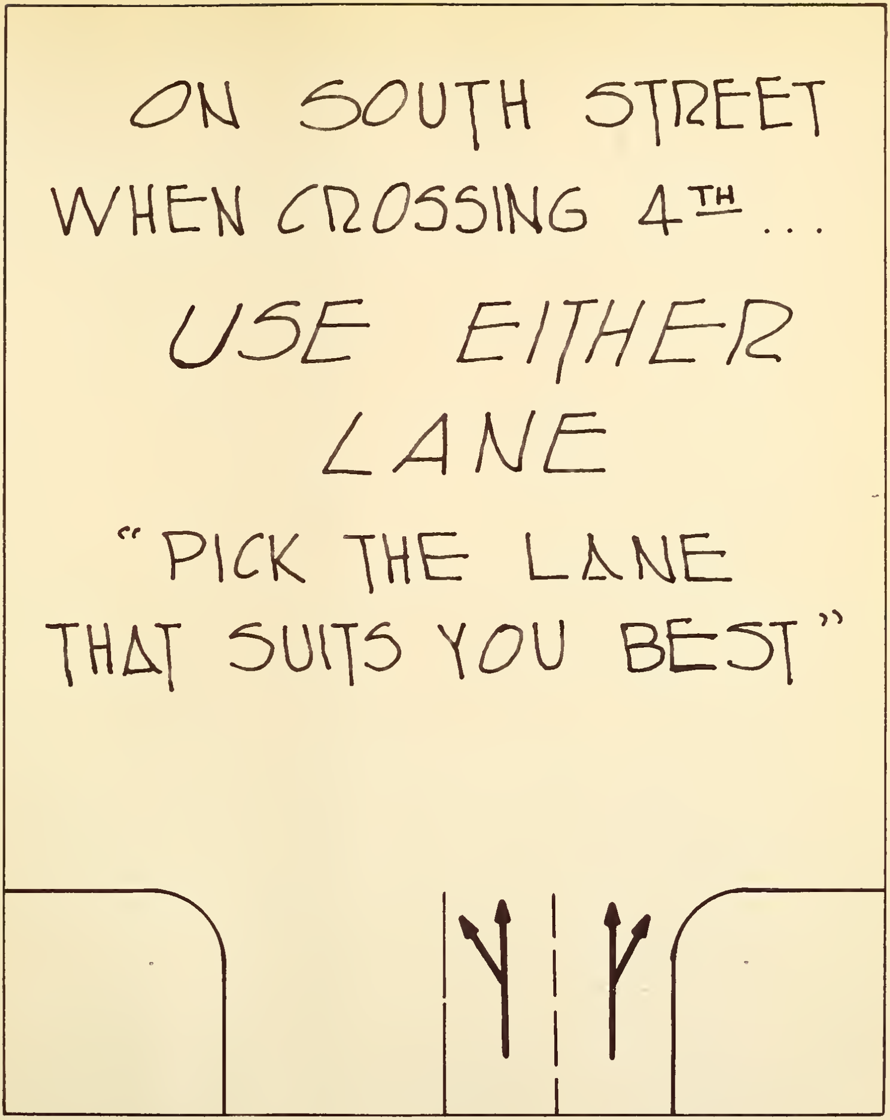


FIGURE 30 INSTRUCTION SHEET PASSED OUT TO MOTORIST